Aerobic degradation of Dicamba in four soils

Report:	MRID 50931306. Habeeb, S.B. 2019. [Phenyl-UL-^{14}C] Dicamba - Aerobic Degradation in Four Soils. Unpublished study performed by Smithers Viscient, Wareham, Massachusetts; sponsored and submitted by Dicamba Registrants Coalition, c/o Wagner Regulatory Associates, Hockessin, Delaware. Smithers Viscient Study No.: 14166.6101. Experiment initiated October 31, 2018 and terminated March 22, 2019 (p. 16). Study completed July 25, 2019.
Document No.:	MRID 50931306
Guideline:	OCSPP 835.4100
Statements:	The study was conducted in accordance with USEPA FIFRA GLP (40 CFR Part 160) and OECD Principles of GLP standards (p. 3). Signed and dated Data Confidentiality, GLP, and Quality Assurance statements were provided (pp. 2-4). The authenticity of the report is certified in the Quality Assurance Statement (p. 4).
Classification:	This study is **acceptable**. The pesticide use histories for three of the four soil collection sites were not reported, however the collection information indicated the areas were pesticide free. While unextracted residues were > 66% for all four soils at 120 days, additional extraction using polar and nonpolar solvents only released ≤2.66% additional radioactivity. As a result, the unextracted residues are considered strongly bound.
PC Code:	029801

Final EPA Reviewer:	Chuck Peck Senior Fate Scientist	Signature: Date: 2020.11.23 10:32:37 -05'00'
CDM/CSS-Dynamac JV Reviewers:	Joan Harlin, M.S., Environmental Scientist	Signature: Date: 4/29/20
	Joan Gaidos, Ph.D. Environmental Scientist	Signature: Date: 4/29/20

This Data Evaluation Record may have been altered by the Environmental Fate and Effects Division subsequent to signing by CDM/CSS-Dynamac JV personnel. The CDM/CSS-Dynamac Joint Venture role does not include establishing Agency policies.

EXECUTIVE SUMMARY

The aerobic transformation of [phenyl-U-^{14}C]dicamba was studied in a loam soil (Hanford, pH 7.0) from California, a silt loam soil (Fayette, pH 7.2) from Iowa, and sandy loam (MSL, pH 6.6) and loamy sand (RMN, pH 6.9) soils, both from North Dakota, for up to 120 days in darkness at 20°C and a soil moisture content of pF 2.5. The soils were treated at 2.26 mg a.i./kg, equivalent to a field application rate of *ca.* 2.241 kg a.i./ha. Duplicate samples (two entire vessels) of each soil treatment were analyzed at each sampling interval. No determinations were made to verify that aerobic conditions were maintained in the soils. The soils were viable throughout the study.

Overall mass balances averaged 98.9 ± 5.0% of the applied (range 90.1-104.9%) in the loam soil, 100.3 ± 4.3% (range 90.9-107.4%) in the silt loam soil, 99.7 ± 4.9% (range 92.4-110.3%) in the sandy loam soil, and 98.6 ± 3.1% (range 90.3-103.1%) in the loamy sand soil. Recoveries were within guideline criteria (90-110%) except for one sandy loam replicate (110.3%).

Observed DT_{50} values, calculated half-lives, and information on transformation products are listed in **Table 1**. Dicamba dissipated with an SFO DT50 values of 15.1 days in the loam soil, 9.46 days in the silt loam soil, 7.62 days in the sandy loam soil, and 11.4 days in the loamy sand soil. One major transformation product, DCSA, was identified.

In the Hanford loam soil, extractable radioactivity declined from a maximum of 101.4% of the applied at 0 days posttreatment to 6.4% at 120 days. Unextracted radioactivity increased to a maximum of 67.7% at 120 days. Further extraction of the 120-day extracted soil with tetrahydrofuran and hexane released ≤1.35% additional radioactivity. Further analysis of the 120-day unextracted residues determined that 22.6-28.0% of the applied radioactivity was associated with the fulvic acid fraction, 1.66-2.80% with the humic acid fraction, and 32.4-35.5% with the humin fraction. CO_2 totaled a maximum of 25.6% of the applied at study termination. Organic volatiles (traps + foam plugs) were ≤1.9% of the applied at all sampling intervals.

In the Fayette silt loam soil, extractable radioactivity declined from a maximum of 104.3% of the applied at 0 days posttreatment to 7.8% at 120 days. Unextracted radioactivity increased to a maximum of 72.2% of the applied at 120 days. Further extraction of the 120-day extracted soil with tetrahydrofuran and hexane released ≤1.59% additional radioactivity. Further analysis of the 120-day unextracted residues determined that 22.8-23.9% of the applied radioactivity was associated with the fulvic acid fraction, 1.24-1.25% with the humic acid fraction, and 40.5-45.5% with the humin fraction. CO_2 totaled a maximum of 27.3% of the applied at study termination. Organic volatiles (traps + foam plugs) were ≤0.088% of the applied at all sampling intervals.

In the MSL sandy loam soil, extractable radioactivity declined from a maximum of 95.6% of the applied at 0 days posttreatment to 8.4% at 120 days. Unextracted radioactivity increased to a maximum of 71.0% of the applied at 30 days, and was 64.6% at 120 days. Further extraction of the 120-day extracted soil with tetrahydrofuran and hexane released ≤1.83% additional radioactivity. Further analysis of the 120-day unextracted residues determined that 22.2-24.6% of the applied radioactivity was associated with the fulvic acid fraction, 0.59-0.92% with the humic acid fraction, and 36.2-37.7% with the humin fraction. CO_2 totaled a maximum of 34.2% of the applied at study termination. Organic volatiles (traps + foam plugs) were ≤0.019% of the applied at all sampling intervals.

In the RMN loamy sand soil, extractable radioactivity declined from a maximum of 100.9% of the applied at 0 days posttreatment to 11.0% at 120 days. Unextracted radioactivity increased to a maximum of 66.2% at 120 days. Further extraction of the 120-day extracted soil with tetrahydrofuran and hexane released ≤2.66% additional radioactivity. Further analysis of the 120-day unextracted residues determined that 19.5-23.9% of the applied radioactivity was associated with the fulvic acid fraction, 5.88-6.99% with the humic acid fraction, and 33.9-35.9% with the humin fraction. CO_2 totaled a maximum of 26.1% of the applied at study termination. Organic volatiles (traps + foam plugs) were ≤0.018% of the applied at all sampling intervals.

Table 1. Results Synopsis: Aerobic Soil Metabolism of Dicamba.

Soil Location and Texture (Temperature, pH)	Observed DT_{50} (days)	Calculated Half-life[2] (days)	Model Parameters and Statistics	Transformation Products (maximum % AR, associated interval)[1,2]	
				Major	Minor
California USA Hanford Loam soil (20°C, pH 7.0)	14-21	15.1 SFO	C_0 = 110 k = 0.0458 S_c = 1.79e+03 S_{SFO} = 1.91e+03	DCSA (33.4%, 30 days) Unextracted residues (67.7%, 120 days) CO_2 (25.6%, 120 days)	None
Iowa USA Fayette Silt loam soil (20°C, pH 7.2)	14-21	9.46 SFO	C_0 = 106 k = 0.0733 S_c = 1.19e+03 S_{SFO} = 1.19e+03	DCSA (29.6%, 21 days) Unextracted residues (72.2%, 120 days) CO_2 (27.3%, 120 days)	None
North Dakota USA MSL Sandy loam soil (20°C, pH 6.6)	7-14	7.62 SFO	C_0 = 94.7 k = 0.0909 S_c = 265 S_{SFO} = 243	DCSA (35.6%, 14 days) Unextracted residues (71.0%, 30 days) CO_2 (34.2%, 120 days)	None
North Dakota USA RMN Loamy sand soil (20°C, pH 6.9)	7-14	11.4 SFO	C_0 = 100 k = 0.061 S_c = 382 S_{SFO} = 397	DCSA (26.1%, 30 days) Unextracted residues (66.2%, 120 days) CO_2 (26.1%, 120 days)	None

1 Calculated half-lives, model parameters, and kinetics models in accordance with the NAFTA kinetics guidance; Indeterminate Order Rate Equation (IORE), and Single First Order (SFO).
2 AR means "applied radioactivity".

I. Materials and Methods

A. Materials:

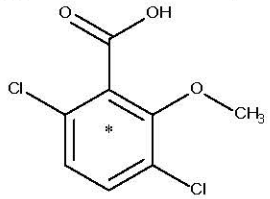
1. Test Material [Phenyl-U-^{14}C]-labeled dicamba (p. 17; Appendix 2, p. 101).

Specific activity: 83 mCi/mmol; 826,278 dpm/µg

Radiochemical purity: 99.1%

Chemical purity: 98.1% (p. 101)

Lot No.: TJBIOS-NLH-2-8



Solubility in water: Not reported

2. Reference Compounds: The following standards were used in the analysis (**Table 2**).

Table 2. Reference Compounds.

Applicant's Code Name	IUPAC Chemical Name	Purity (%)	Lot/Batch No.	Expiration Date
Dicamba acid (Dicamba)	3,6-Dichloro-o-anisic acid	99.0	DMBT01612B	9/8/2019
DCSA (3,6-Dichlorosalicylic acid)	3,6-Dichloro-2-hydroxybenzoic acid	99.0	7730700	1/31/2022
2,5-Dichloro-3,6-dihydroxybenzoic acid	2,5-Dichloro-3,6-dihydroxybenzoic acid	95.0	2017-0155653	Not specified
Dicamba methyl ester	Methyl 3,6-dichloro-2-methoxybenzoate	99.5	BCBW0475	10/2021
Dicamba-5-hydroxy	2,5-Dichloro-3-hydroxy-6-methoxybenzoic acid	99.0	H168077AL	1/18/2021

Data obtained from pp. 17-18 and Appendix 2, pp. 101-106 of the study report. IUPAC Chemical names from DER Attachment 1.

3. Soil: Soil collection and characterization are summarized in **Table 3** and **Table 4**, respectively.

Table 3. Description of Soil Collection and Storage.

Description	Hanford Loam	Fayette Silt loam	MSL Sandy loam	RMN-LS Loamy sand
Geographic location	Hickman, California	Fayette, Iowa	North Dakota	North Dakota
GPS Coordinates	37° 36' 24.2' N 120° 45' 2.5" W	42° 13.3902' N 90° 29.4684' W	47° 48.145' N 97° 37.237" W	47° 41.961' N 97° 31.020' W
Site Description	Non-cropped ground (fallow)	Level; grass	Level; grass	Level; grass
Soil series	Hanford	Not reported	Not reported	Not reported
Pesticide use history at the collection site	The soil was not treated with the test substance or its structural analogs during the last 5 years.	Pesticide-free site. Pesticide use history not reported.	Pesticide-free site. Pesticide use history not reported.	Pesticide-free site. Pesticide use history not reported.
Collection date	September 19, 2018	September 23, 2018	October 18, 2018	September 27, 2018
Collection procedures	A shovel and a clean 5-gallon bucket.	Shovel.	Shovel.	Shovel.
Sampling depth	0-20 cm	0-6 inches	0-6 inches	0-6 inches
Storage conditions	Not reported			
Storage length	Not reported			
Soil preparation	Sieved (2 mm)			

Data obtained from p. 19; Table 1, p. 40; and Appendix 3, pp. 108-117 of the study report.

Table 4. Properties of the Soils.

Property	Hanford	Fayette	MLS	RMN
Soil Texture (USDA)	Loam	Silt loam	Sandy loam	Loamy sand
% Sand	37	29	64	83
% Silt	42	54	17	10
% Clay	21	17	19	7
pH (1:1 water:soil)	7.0	7.2	6.6	6.9
pH (0.01M $CaCl_2$)	6.6	6.8	6.2	6.5
Organic carbon (%)[1]	0.87	2.3	2.15	2.1
Organic matter (%)	1.5	3.9	3.7	3.6
Cation Exchange Capacity (meq/100 g)	11.1	13.2	15.9	13.3
$CaCO_3$ equivalence (%)	Not reported.			
Soil Moisture Content (%)				
1/10 Bar (pF 2.0)	27.1	43.2	28.0	24.9
1/3 Bar (pF 2.5)	22.8	31.5	23.6	15.2
15 Bar (pF 4.2)	10.9	18.2	14.7	11.7
Bulk density (g/cm^3, disturbed)	1.17	1.00	1.05	1.10
Microbial Biomass (mg C/100 g soil)				
Post-handling*	22.8	26.4	28.7	24.3
Start*	34.4	18.4	32.2	19.4
End*	10.5	25.3	13.9	18.2
Soil taxonomic classification	Not reported.			

Data obtained from Tables 1-2, pp. 40-41 of the study report. The soil texture was confirmed using USDA-NRCS technical support tools.

*"Post-handling", "Start", and "End" days were not defined.
[1] Calculated by the reviewer as: organic carbon (%) = organic matter (%)/1.72.

B. STUDY DESIGN

1. Experimental Conditions: (Summarized in **Table 5**).

Table 5. Experimental Design.

Property	Hanford Loam	Fayette Silt loam	MSL Sandy loam	RMN Loamy sand
Duration of the test (hours)	120 days			
Soil condition (Air dried/fresh)	Acclimated under study conditions for 6-7 days prior to use.			
Soil (g/replicate, dry wt)	50 g			
Application rates				
Nominal	2.24 µg a.i./g, equivalent to a maximum field rate of *ca.* 2241 g a.i./ha.[1]			
Actual	2.26 µg a.i./g			
Control conditions (if used)	Same as with the definitive test.			
Number of Replicates				
Controls (if used)	Duplicate solvent controls used measuring biomass for each test soil were collected near the start and near the end of the experiment.			
Treatment	Duplicate samples (two entire vessels) of each soil were collected at each sampling interval.			
Test apparatus				
Type/material/volume	Glass screw-cap vessels (250-mL volume) containing moist soil were attached to flow-through volatile trapping systems. Humidified air was drawn through the test systems via vacuum (flow rate not reported). Samples were equilibrated for 6-7 days prior to treatment. Samples were incubated in darkness at 20 ± 2°C.			
Details of traps for CO_2 and other volatiles (if any)	One polyurethane foam plug, and one tube containing ethylene glycol trapping solution, and three tubes containing 2.5N NaOH trapping solution. The volatile trapping system is illustrated on p. 23 of study.			
If no traps were used, is the system closed/open?	Volatile traps were used.			
Identity and concentration of co-solvent	Acetonitrile			
Test Material:				
Volume of the test solution used/treatment	135 µL/sample			
Application method	Hamilton syringe			
Is the co-solvent evaporated?	No			
Any indication of the test material adsorbing to the walls of the test apparatus?	None			
Experimental conditions:				
Temperature (°C)	20 ± 2°C (range 18.9-22.0°C)			
Continuous darkness	Yes			
Moisture content	pF 2.5			
Moisture maintenance method	Soil moisture was checked periodically throughout the incubation period by weighing the soil samples. Purified reagent water was added, if needed, to maintain the soil moisture at pF 2.5.			
Other details (if any)	Eight solvent controls were dosed with 135 µL of acetonitrile and incubated to determine soil biomass.			

Data obtained from pp. 19, 22-23, and 30 of the study report.

[1] Assumes a soil density of 1.0 g/cm^3 and a uniform incorporation to a depth of 10 cm (p. 22).

2. Sampling During Study Period: (Details summarized in **Table 6**).

Table 6. Sampling During Study Period.

Criteria	Details
Sampling intervals (hours)	0, 3, 7, 14, 21, 30, 44, 63, 91, and 120 days.
Sampling method	Duplicate samples (two entire vessels) of each soil were collected at each sampling interval.
Method of collection of CO_2 and organic volatile compounds	Volatile trapping solutions were collected at each sampling interval beginning on Day 3.
Sampling intervals/times for:	
Sterility check (if used)	None.
Moisture content	Soil moisture was checked periodically throughout the incubation period by weighing the soil samples. Purified reagent water was added, if needed, to maintain the soil moisture at pF 2.5.
Redox potential, other	Redox potential was not measured.
Sample storage before analysis	Soil extracts were processed and analyzed immediately after sampling. Soil samples and unextracted residues not directly needed for analysis were stored in a freezer. Volatile solution samples were stored at room temperature.
Other observation (if any)	None.

Data obtained from pp. 19, 24, and 28 of the study report.

3. Analytical Procedures: The extraction methods used in the definitive study were selected based on the results of preliminary testing (p. 27; Appendix 4, pp. 118-138).

Extraction Methods: The soil was sequentially extracted twice with acetonitrile:purified reagent water (1:1, v:v) and once with acetonitrile:purified reagent water:HCl (50:50:0.1, v:v:v; p. 24) followed by shaking (60 minutes/extraction at 200 rpm; p. 24). After each extraction, the mixture was centrifuged for 10 minutes (3,500 rpm) and the supernatant was decanted. The extracts were combined and aliquots analyzed using liquid scintillation counting (LSC). A portion of the combined extracts was concentrated to dryness under vacuum by rotary evaporation at 30°C. The concentrated sample was transferred to a graduated glass conical tube, the flask was rinsed with acetonitrile:purified reagent water:HCl (50:50:0.1, v:v:v), and the concentrated sample was vortex mixed for *ca.* 10 seconds and shaken well to mix. A portion of the concentrate was centrifuged for 5 minutes (10,000 rpm) and analyzed using LSC. A portion of the centrifuged sample was analyzed by high performance liquid chromatography with radiometric detection (HPLC-RAM).

Determination of Unextracted Residues (UER): The soils remaining after extraction were homogenized and combusted using a Harvey Oxidizer, followed with analysis for total radioactivity by LSC (p. 25).

Following combustion analysis, 120-day samples were further extracted once with *ca.* 150 mL of tetrahydrofuran and once with *ca.* 150 mL of hexane by shaking (60 minutes/extraction at 200 rpm; pp. 25-26). After each extraction, the mixture was centrifuged and the supernatant decanted. Aliquots of the individual extracts were analyzed using LSC.

Following the polar and non-polar extractions, a portion of the remaining solids from each sample was subjected to organic matter fractionation (p. 26). A wet soil sample (*ca.* 10 g) was transferred to a centrifuge tube and allowed to air dry for *ca.* 2 hours. Then, *ca.* 25 mL of 2M NaOH was added, and the samples were sonicated for 2 minutes and then shaken at room temperature for 30 minutes (*ca.* 200 rpm). Samples were then centrifuged for 10 minutes (*ca.* 3,000 rpm) to pellet the solids and

the supernatants were decanted. The extraction was repeated twice, the supernatants were pooled, and aliquots were analyzed using LSC.

The combined NaOH extracts were adjusted to pH <1 with concentrated HCl to precipitate the humic acid fraction (p 26). The samples were centrifuged for 10 minutes (*ca.* 3,000 rpm) to pellet any precipitate. The supernatant containing the fulvic acid fraction was decanted and aliquots were analyzed using LSC. The remaining precipitate containing the humic acid fraction was resuspended in 2M NaOH and aliquots were analyzed using LSC to quantify the humic acid fraction. The concentration of residues remaining in the soil (humin) was determined by subtraction.

Determination of Volatile Compounds: Aliquots of the ethylene glycol and NaOH trapping solutions were analyzed using LSC (p. 27). The polyurethane foam plugs (PUFs) from each volatile trapping system were extracted with 100 mL of acetonitrile by sonicating for 5 minutes; the foam plug was squeezed with a spatula, the extract was decanted, and aliquots were analyzed using LSC. The presence of CO_2 in representative 120-day NaOH solutions containing ≥5% of the applied radioactivity was confirmed by precipitation with barium carbonate.

Total radioactivity measurement: Total [^{14}C]residues were determined by summing the concentrations of residues in the soil extracts, extracted soil, and volatile trapping solutions (p. 29).

Derivatization method: A derivatization method was not employed.

Identification and quantification of Parent and Transformation Compounds: Aliquots of the soil extracts were analyzed by HPLC-RAM using a Phenomenex Luna C18(2) analytical column (5 µm, 250 x 4.6 mm) eluted with a gradient mobile phase of (A) 0.1% trifluoroacetic acid in purified reagent water and (B) 0.1% trifluoroacetic acid in acetonitrile (80:20 to 10:90; v:v; pp. 27-28; Appendix 4, pp. 120-121). The eluate was monitored with radioactivity and UV detectors. Peak retention times were compared to those of reference standards that were cochromatographed with the samples.

Detection Limits (LOD, LOQ) for the Parent and Transformation Products: For HPLC-RAM, the Limit of Detection (LOD) was set to be 100 dpm and the Limit of Quantification (LOQ) was set to be three times the LOD (pp. 28-29). The LOD/LOQ are provided in the table below (Table 4, p. 43):

Background Matrix	Average LOD (% AR)	Average LOQ (% AR)
Acetonitrile	0.021	0.065
Acetonitrile:purified reagent water (1:1, v:v)	0.033	0.100
Acetonitrile:purified reagent water:HCl (50:50:0.1, v:v:v)	0.033	0.100
2.5N NaOH	0.001	0.002
Ethylene glycol	0.001	0.002
Harvey cocktail (UER)	0.085	0.198
Tetrahydrofuran	0.067	0.147
Hexane	0.035	0.103

II. Results and Discussion

A. Data

Study results including total mass balances and distribution of radioactivity are presented in **Tables 7a-7d**. No determinations were made to verify that aerobic conditions were maintained in the soils. Soils used were viable at study initiation, middle, and termination (Table 2, p. 41).

B. Mass Balance

Overall mass balances averaged 98.9 ± 5.0% of the applied (range 90.1-104.9%) in the loam soil, 100.3 ± 4.3% (range 90.8-107.4%) in the silt loam soil, 99.7 ± 4.9% (range 92.4-110.3%) in the sandy loam soil, and 98.6 ± 3.1% (range 90.3-103.1%) in the loamy sand soil (Tables 5-8, pp. 44-47). Recoveries were within guideline criteria (90-110%) except for one sandy loam replicate (110.3%).

C. Unextracted and Extractable Residues

In the Hanford loam soil, extractable radioactivity declined from a maximum of 101.4% of the applied at 0 days posttreatment to 6.4% at 120 days (Table 5, p. 44). Unextracted radioactivity increased to a maximum of 67.7% at 120 days. Further extraction of the 120-day extracted soil with tetrahydrofuran and hexane released ≤1.35% additional radioactivity (pp. 31-32). Further analysis of the 120-day unextracted residues determined that 22.6-28.0% of the applied radioactivity was associated with the fulvic acid fraction, 1.66-2.80% with the humic acid fraction, and 32.4-35.5% with the humin fraction (p. 32).

In the Fayette silt loam soil, extractable radioactivity declined from a maximum of 104.3% of the applied at 0 days posttreatment to 7.8% at 120 days (Table 6, p. 45). Unextracted radioactivity increased to a maximum of 72.2% of the applied at 120 days. Further extraction of the 120-day extracted soil with tetrahydrofuran and hexane released ≤1.59% additional radioactivity (pp. 31-32). Further analysis of the 120-day unextracted residues determined that 22.8-23.9% of the applied radioactivity was associated with the fulvic acid fraction, 1.24-1.25% with the humic acid fraction, and 40.5-45.5% with the humin fraction (p. 32).

In the MSL sandy loam soil, extractable radioactivity declined from a maximum of 95.6% of the applied at 0 days posttreatment to 8.4% at 120 days (Table 7, p. 46). Unextracted radioactivity increased to a maximum of 71.0% of the applied at 30 days and was 64.6% at 120 days. Further extraction of the 120-day extracted soil with tetrahydrofuran and hexane released ≤1.83% additional radioactivity (pp. 31-32). Further analysis of the 120-day unextracted residues determined that 22.2-24.6% of the applied radioactivity was associated with the fulvic acid fraction, 0.59-0.92% with the humic acid fraction, and 36.2-37.7% with the humin fraction (p. 32).

In the RMN loamy sand soil, extractable radioactivity declined from a maximum of 100.9% of the applied at 0 days posttreatment to 11.0% at 120 days (Table 8, p. 47). Unextracted radioactivity increased to a maximum of 66.2% at 120 days. Further extraction of the 120-day extracted soil with tetrahydrofuran and hexane released ≤2.66% additional radioactivity (pp. 31-32). Further analysis of the 120-day unextracted residues determined that 19.5-23.9% of the applied radioactivity was

associated with the fulvic acid fraction, 5.88-6.99% with the humic acid fraction, and 33.9-35.9% with the humin fraction (p. 32).

D. Volatilization

CO_2 totaled maximums of 25.6% of the applied in the loam soil, 27.3% in the silt loam soil, 34.2% in the sandy loam soil, and 26.1% in the loamy sand soil at 120 days posttreatment (Tables 5-8, pp. 44-47). Organic volatiles (traps + foam plugs) were ≤1.9% of the applied in the loam soil, ≤0.088% in the silt loam soil, ≤0.019% in the sandy loam soil, and ≤0.018% in the loamy sand soil at all sampling intervals.

Table 7a. Transformation of [phenyl-^{14}C]dicamba, expressed as a percentage of applied radioactivity, in aerobic Hanford loam soil.

Sampling Interval (days)	0		3		7		14		21		30	
Replicate	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Dicamba	101.4	101.1	93.6	93.4	89.4	89.6	80.9	80.8	32.0	32.7	19.9	20.4
DCSA	<LOD	<LOD	5.1	4.1	6.2	5.8	9.9	11.9	31.4	30.6	31.8	33.4
TP 1	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	1.5	1.4	3.1	3.7
TP 2	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 3	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 4	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 5	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 6	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Polars	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	1.0	0.79	<LOD	<LOD
Others	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0.0065	<LOD	<LOD
Extracted residues	101.4	101.1	98.7	97.5	95.6	95.4	90.8	92.7	65.9	65.5	54.8	57.5
Unextracted residues	0.29	0.31	3.4	3.2	5.7	5.8	8.7	8.8	30.9	32.5	36.7	40.7
CO_2	n.a.	n.a.	0.45	0.45	1.0	1.0	2.3	2.3	3.9	3.9	6.7	6.7
VOC - foam plugs	n.a.	n.a.	<LOQ	<LOQ	0.0025	0.0025	0.0055	0.0055	0.011	0.011	0.025	0.025
VOC - ethylene glycol	n.a.	n.a.	<LOQ	<LOQ	0.0067	0.0067	0.011	0.011	0.015	0.015	0.024	0.024
Total VOC	n.a.	n.a.	0.0000	0.0000	0.0092	0.0092	0.016	0.016	0.026	0.026	0.049	0.049
Mass balance	101.7	101.4	102.6	101.2	102.3	102.2	101.8	103.8	100.7	101.9	98.2	104.9

Data obtained from Table 5, p. 44 and Table 9, p. 48 of the study report.
VOC = Volatile organic compounds.
<LOD = Less than the Limit of Detection; <LOQ = Less than the Limit of Quantification; n.a. = not analyzed.

Table 7a (continued). Transformation of [phenyl-^{14}C]dicamba, expressed as a percentage of applied radioactivity, in aerobic Hanford loam soil.

Sampling Interval (days)	44		63		91		120	
Replicate	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Dicamba	5.3	6.4	1.1	1.3	1.8	1.7	0.72	1.4
DCSA	25.6	27.5	10.9	10.9	4.1	4.4	2.1	2.7
TP 1	2.7	2.9	1.7	2.0	0.48	0.79	<LOD	<LOD
TP 2	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 3	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0.84	0.52
TP 4	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0.64	<LOD
TP 5	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 6	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Polars	1.5	<LOD	1.0	1.6	1.4	4.0	1.6	1.8
Others	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Extracted residues	35.1	36.8	14.7	15.8	7.8	10.9	5.9	6.4
Unextracted residues	54.8	53.9	62.9	61.0	61.9	58.5	67.7	57.9
CO_2	9.5	9.5	13.8	13.8	20.5	20.5	25.6	25.6
VOC - foam plugs	0.072	0.072	0.13	0.13	0.20	0.20	0.20	0.20
VOC - ethylene glycol	0.028	0.028	0.035	0.035	0.035	0.035	1.7	1.7
Total VOC	0.100	0.100	0.165	0.165	0.235	0.235	1.9	1.9
Mass balance	99.5	100.3	91.5	90.8	90.4	90.1	101.1	91.8

Data obtained from Table 5, p. 44 and Table 9, p. 48 of the study report.
VOC = Volatile organic compounds.
<LOD = Less than the Limit of Detection; <LOQ = Less than the Limit of Quantification;
n.a. = not analyzed.

Table 7b. Transformation of [phenyl-^{14}C]dicamba, expressed as a percentage of applied radioactivity, in aerobic Fayette silt loam soil.

Sampling Interval (days)	0		3		7		14		21		30	
Replicate	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Dicamba	101.1	104.3	82.4	82.7	67.9	67.1	54.3	54.9	9.3	10.6	1.3	0.90
DCSA	<LOD	<LOD	8.7	8.2	11.5	12.9	17.0	15.6	29.6	28.5	13.5	16.5
TP 1	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	1.3	0.29	0.67
TP 2	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 3	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 4	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 5	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 6	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Polars	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	1.7	1.1	2.4	2.1
Others	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Extracted residues	101.1	104.3	91.1	90.9	79.4	80.0	71.3	70.5	40.6	41.6	17.6	20.2
Unextracted residues	0.65	0.66	9.2	10.3	20.3	17.2	23.4	24.3	50.6	47.3	61.0	60.3
CO_2	n.a.	n.a.	1.9	1.9	3.6	3.6	7.0	7.0	7.1	7.1	12.2	12.2
VOC - foam plugs	n.a.	n.a.	<LOQ	<LOQ	0.0043	0.0043	0.0190	0.0190	0.019	0.019	0.023	0.023
VOC - ethylene glycol	n.a.	n.a.	0.0020	0.0020	0.013	0.013	0.017	0.017	0.017	0.017	0.017	0.017
Total VOC	n.a.	n.a.	0.0020	0.0020	0.0173	0.0173	0.036	0.036	0.036	0.036	0.040	0.040
Mass balance	101.8	105.0	102.2	103.1	103.3	100.8	101.7	101.8	98.3	96.0	90.8	92.7

Data obtained from Table 6, p. 45 and Table 10, p. 50 of the study report.
VOC = Volatile organic compounds.
<LOD = Less than the Limit of Detection; <LOQ = Less than the Limit of Quantification; n.a. = not analyzed.

Table 7b (continued). Transformation of [phenyl-^{14}C]dicamba, expressed as a percentage of applied radioactivity, in aerobic Fayette silt loam soil.

Sampling Interval (days)	44		63		91		120	
Replicate	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Dicamba	1.8	1.9	0.43	0.65	0.31	0.48	0.41	0.42
DCSA	21.7	18.1	10.0	10.8	6.1	3.2	4.1	3.7
TP 1	2.2	2.3	0.93	1.3	0.90	2.1	0.86	1.1
TP 2	<LOD	<LOD	<LOD	0.56	<LOD	<LOD	<LOD	0.56
TP 3	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 4	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0.41	0.36
TP 5	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 6	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Polars	<LOD	<LOD	1.4	1.3	1.1	2.0	1.9	1.7
Others	<LOD	<LOD	<LOD	0.0014	<LOD	<LOD	<LOD	<LOD
Extracted residues	25.7	22.3	12.8	14.1	8.4	7.8	7.6	7.8
Unextracted residues	60.4	65.8	62.6	61.3	70.3	64.0	66.0	72.2
CO_2	16.8	16.8	21.1	21.1	23.7	23.7	27.3	27.3
VOC - foam plugs	0.028	0.028	0.035	0.035	0.035	0.035	0.059	0.059
VOC - ethylene glycol	0.017	0.017	0.017	0.017	0.017	0.017	0.029	0.029
Total VOC	0.045	0.045	0.052	0.052	0.052	0.052	0.088	0.088
Mass balance	102.9	104.9	96.5	96.5	102.4	95.5	101.0	107.4

Data obtained from Table 6, p. 45 and Table 10, p. 50 of the study report.
VOC = Volatile organic compounds.
<LOD = Less than the Limit of Detection; <LOQ = Less than the Limit of Quantification; n.a. = not analyzed.

Table 7c. Transformation of [phenyl-^{14}C]dicamba, expressed as a percentage of applied radioactivity, in aerobic MSL sandy loam soil.

Sampling Interval (days)	0		3		7		14		21		30	
Replicate	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Dicamba	95.6	94.1	68.8	74.0	46.2	51.5	38.6	27.5	9.8	11.5	1.1	3.2
DCSA	<LOD	<LOD	12.8	10.9	26.7	23.1	29.6	35.6	33.2	31.2	18.8	21.7
TP 1	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	1.7	1.7	2.1	2.5
TP 2	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	1.2	0.99	0.56	0.40
TP 3	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 4	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 5	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 6	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Polars	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0.59	1.9	1.7
Others	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Extracted residues	95.6	94.1	81.6	84.9	72.9	74.6	68.2	63.1	45.9	46.0	24.5	29.5
Unextracted residues	0.48	0.42	11.8	10.7	21.8	17.0	24.4	23.9	44.8	46.5	71.0	60.9
CO_2	n.a.	n.a.	1.7	1.7	2.4	2.4	5.5	5.5	9.1	9.1	14.8	14.8
VOC - foam plugs	n.a.	n.a.	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
VOC - ethylene glycol	n.a.	n.a.	<LOQ	<LOQ	0.0024	0.0024	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049
Total VOC	n.a.	n.a.	<LOQ	<LOQ	0.0024	0.0024	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049
Mass balance	96.1	94.5	95.1	97.3	97.1	94	98.1	92.5	99.8	101.6	110.3	105.2

Data obtained from Table 7, p. 46 and Table 11, p. 52 of the study report.
VOC = Volatile organic compounds.
<LOD = Less than the Limit of Detection; <LOQ = Less than the Limit of Quantification; n.a. = not analyzed.

Table 7c (continued). Transformation of [phenyl-^{14}C]dicamba, expressed as a percentage of applied radioactivity, in aerobic MSL sandy loam soil.

Sampling Interval (days)	44		63		91		120	
Replicate	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Dicamba	<LOD	1.1	<LOD	<LOD	<LOD	<LOD	0.40	0.87
DCSA	11.9	10.6	7.8	9.3	3.0	3.0	1.3	1.3
TP 1	4.8	5.0	3.8	4.3	4.6	5.3	2.5	3.5
TP 2	0.56	1.1	<LOD	<LOD	<LOD	<LOD	0.54	0.48
TP 3	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0.44	0.51
TP 4	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0.30	<LOD
TP 5	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0.30	<LOD
TP 6	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Polars	0.87	1.1	1.9	1.7	2.9	2.7	1.5	1.7
Others	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Extracted residues	18.1	18.9	13.5	15.3	10.5	11.0	7.3	8.4
Unextracted residues	63.2	61.1	52.9	60.0	61.3	63.4	60.9	64.6
CO_2	20.6	20.6	26.0	26.0	29.9	29.9	34.2	34.2
VOC - foam plugs	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	0.0083	0.0083
VOC - ethylene glycol	0.0049	0.0049	0.0049	0.0049	0.011	0.011	0.011	0.011
Total VOC	0.0049	0.0049	0.0049	0.0049	0.011	0.011	0.019	0.019
Mass balance	101.9	100.6	92.4	101.3	101.7	104.3	102.4	107.2

Data obtained from Table 7, p. 46 and Table 11, p. 52 of the study report.
VOC = Volatile organic compounds.
<LOD = Less than the Limit of Detection; <LOQ = Less than the Limit of Quantification;
n.a. = not analyzed.

Table 7d. Transformation of [phenyl-^{14}C]dicamba, expressed as a percentage of applied radioactivity, in aerobic RMN loamy sand soil.

Sampling Interval (days)	0		3		7		14		21		30	
Replicate	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Dicamba	100.9	99.6	79.9	79.9	74.3	63.9	39.4	43.0	34.7	37.3	10.2	8.9
DCSA	<LOD	<LOD	11.0	11.1	12.6	16.7	25.5	23.6	23.2	21.7	26.1	24.4
TP 1	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0.88	1.1	2.0	2.2
TP 2	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 3	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 4	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 5	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 6	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Polars	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0.76	0.50	0.78	0.93
Others	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
Extracted residues	100.9	99.6	90.9	91.0	86.9	80.6	64.9	66.6	59.5	60.6	39.1	36.4
Unextracted residues	0.52	0.44	5.8	6.4	10.7	20.1	28.5	27.5	33.9	33.8	51.7	51.7
CO_2	n.a.	n.a.	0.97	0.97	1.6	1.6	3.9	3.9	6.4	6.4	9.6	9.6
VOC - foam plugs	n.a.	n.a.	<LOQ	<LOQ	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024
VOC - ethylene glycol	n.a.	n.a.	0.0024	0.0024	0.0059	0.0059	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093
Total VOC	n.a.	n.a.	0.0024	0.0024	0.0083	0.0083	0.0117	0.0117	0.0117	0.0117	0.0117	0.0117
Mass balance	101.4	100.0	97.7	98.4	99.2	102.3	97.3	98.0	99.9	100.8	100.4	97.7

Data obtained from Table 8, p. 47 and Table 12, p. 54 of the study report.
VOC = Volatile organic compounds.
<LOD = Less than the Limit of Detection; <LOQ = Less than the Limit of Quantification; n.a. = not analyzed.

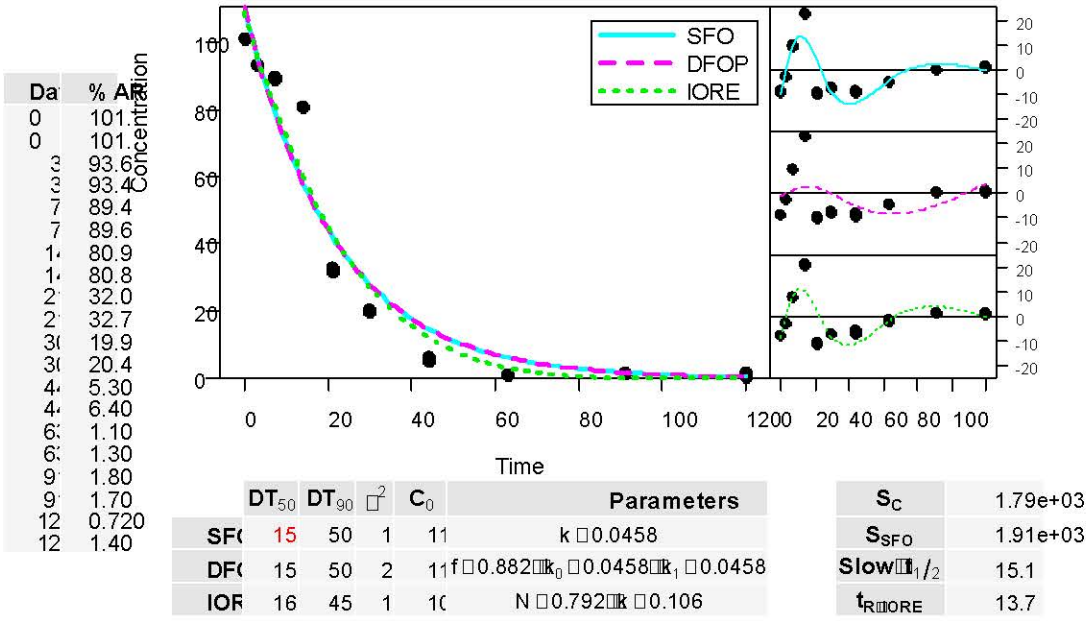
Table 7d (continued). Transformation of [phenyl-^{14}C]dicamba, expressed as a percentage of applied radioactivity, in aerobic RMN loamy sand soil.

Sampling Interval (days)	44		63		91		120	
Replicate	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Dicamba	1.6	1.9	1.1	0.83	0.42	0.52	0.71	0.60
DCSA	21.5	22.1	14.4	13.8	9.3	4.6	2.2	2.4
TP 1	2.9	3.2	3.9	3.6	3.5	5.8	5.0	4.1
TP 2	<LOD	<LOD	0.59	<LOD	<LOD	0.47	0.44	0.74
TP 3	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0.49	0.68
TP 4	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 5	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
TP 6	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	0.44	0.56
Polars	1.0	1.3	1.8	1.7	2.3	3.7	1.6	1.7
Others	0.0027	0.0028	<LOD	0.64	<LOD	<LOD	<LOD	<LOD
Extracted residues	27.0	28.5	21.8	20.6	15.5	15.1	10.7	10.8
Unextracted residues	57.3	56.3	54.9	60.6	53.6	51.3	65.1	66.2
CO_2	13.3	13.3	18.2	18.2	23.9	23.9	26.1	26.1
VOC - foam plugs	0.0024	0.0024	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083
VOC - ethylene glycol	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093
Total VOC	0.0117	0.0117	0.0176	0.0176	0.0176	0.0176	0.0176	0.0176
Mass balance	97.6	98.1	94.9	99.4	93.0	90.3	101.9	103.1

Data obtained from Table 8, p. 47 and Table 12, p. 54 of the study report.
VOC = Volatile organic compounds.
<LOD = Less than the Limit of Detection; <LOQ = Less than the Limit of Quantification
n.a. = not analyzed.

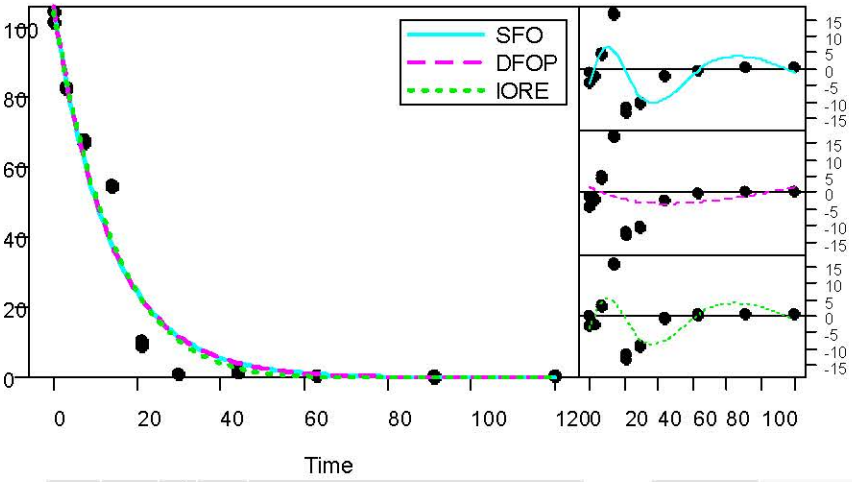
E. Transformation of the Test Compound: Transformation kinetics of dicamba are summarized in the following **Figures**. Transformation kinetics of DCSA are presented in DER Attachment 2.

Aerobic metabolism of dicamba in Hanford loam soil



Aerobic metabolism of dicamba in Fayette silt loam soil

Da	% AR
0	101.
0	104.
3	82.4
3	82.7
7	67.9
7	67.1
1	54.3
1	54.9
2	9.30
2	10.6
3	1.30
3	0.900
4	1.80
4	1.90
6	0.430
6	0.650
9	0.310
9	0.480
12	0.410
12	0.420

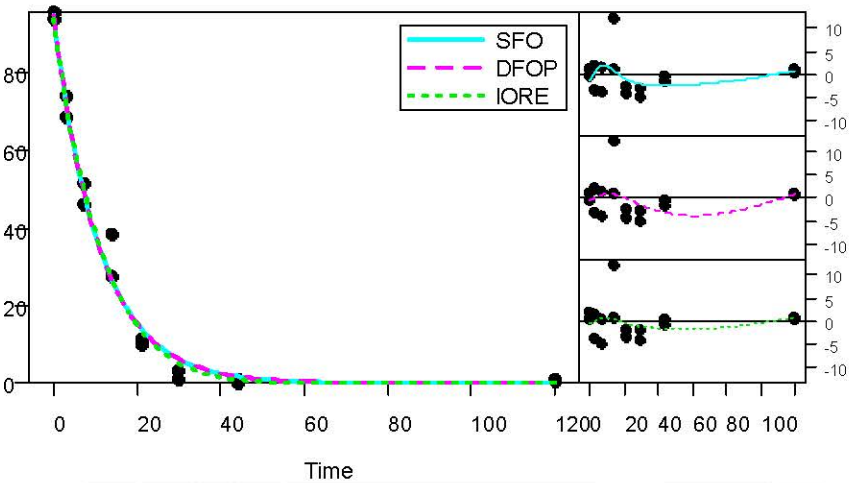


	DT_{50}	DT_{90}	χ^2	C_0	Parameters
SF	9.4	31	1	1	k 0.0733
DF	9.4	31	2	1	f 0.0792 k_0 0.0733 k_1 0.0733
IOR	9.9	30	1	1	N 0.875 k 0.119

S_C	1.19e+03
S_{SFO}	1.19e+03
Slow $DT_{1/2}$	9.46
t_{R} IORE	9.05

Aerobic metabolism of dicamba in MSL sandy loam soil

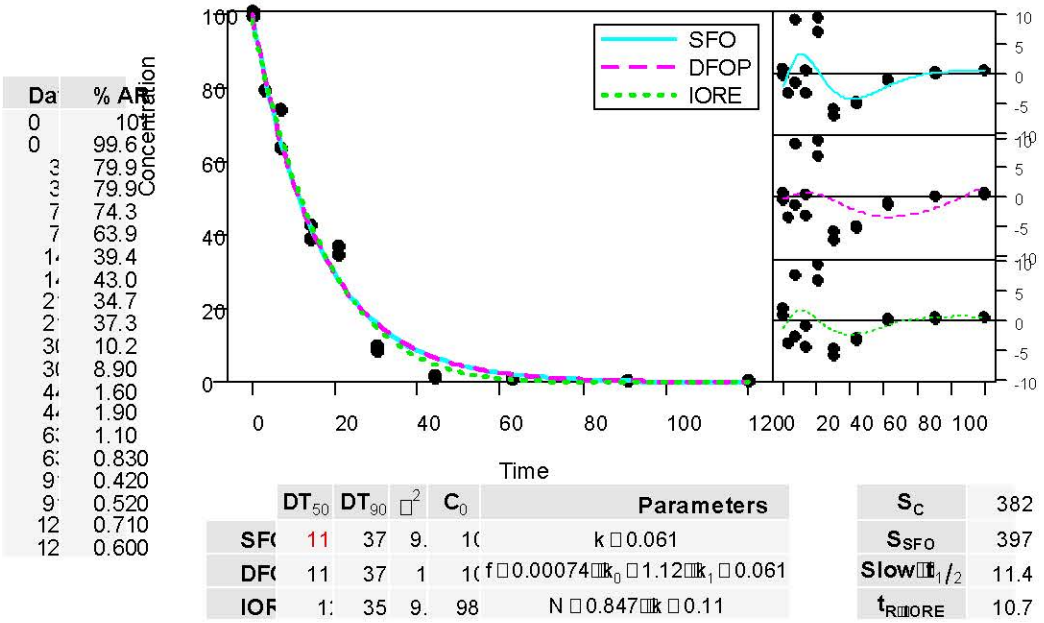
Da	% AR
0	95.6
0	94.1
3	68.8
3	74.0
7	46.2
7	51.5
1	38.6
1	27.5
2	9.80
2	11.5
3	1.10
3	3.20
4	0.100
4	1.10
12	0.400
12	0.870



	DT_{50}	DT_{90}	χ^2	C_0	Parameters
SF	7.6	25	7.	94	k 0.0909
DF	7.6	25	8.	94	f 0.96 k_0 0.0909 k_1 0.0909
IOR	7.9	24	7.	93	N 0.901 k 0.132

S_C	265
S_{SFO}	243
Slow $DT_{1/2}$	7.63
t_{R} IORE	7.35

Aerobic metabolism of dicamba in RMN loamy sand soil



Da	% AR
0	10
0	99.6
3	79.9
3	79.9
7	74.3
7	63.9
1	39.4
1	43.0
2	34.7
2	37.3
3	10.2
3	8.90
4	1.60
4	1.90
6	1.10
6	0.830
9	0.420
9	0.520
12	0.710
12	0.600

	DT_{50}	DT_{90}	χ^2	C_0	Parameters
SF	11	37	9.	1	k 0.061
DF	11	37	1	1	f 0.00074 k_0 1.12 k_1 0.061
IOR	1	35	9.	98	N 0.847 k 0.11

S_C	382
S_{SFO}	397
Slow $t_{1/2}$	11.4
t_{RIORE}	10.7

Kinetics models: Single First Order (SFO); Double First Order in Parallel (DFOP), and Indeterminate Order Rate Equation (IORE). Calculated half-lives and model parameters in accordance with the NAFTA kinetics guidance.

Using CAKE (v. 3.3) software, the study author determined SFO DT50 values of 15.1 days in the Hanford loam soil, 9.46 days in Fayette silt loam soil, 7.62 days in the MSL sandy loam soil, and 11.4 days in the RMN loamy sand soil for dicamba and SFO DT50 values of 23.6 days in the Hanford loam soil, 27.8 days in Fayette silt loam soil, 14.2 days in the MSL sandy loam soil, and 25.0 days in the RMN loamy sand soil for DCSA (pp. 28-30; 34-35; Appendix 7, pp. 158-194). Using PestDF software, the reviewer determined the same DT50 for dicamba as the study authors and SFO DT50 values of 23.3 days in the Hanford loam soil, 32.1 days in Fayette silt loam soil, 22 days in the MSL sandy loam soil, and 33.1 days in the RMN loamy sand soil for DCSA (Attachment 2).

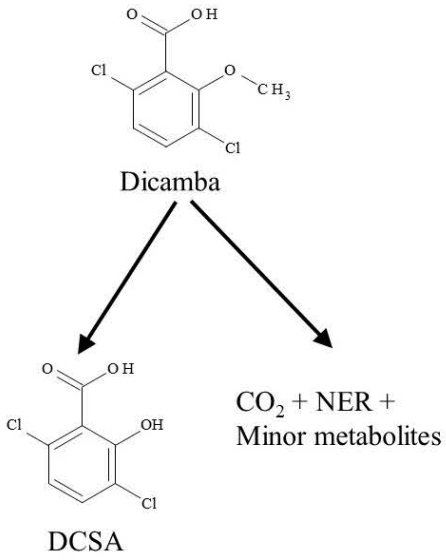
Observed transformation products are described in **Table 8**.

Table 8. Transformation Products of Dicamba in Aerobic Soils.

	Transformation Products	Maximum %AR Observed	Associated Interval (days)	Final %AR Observed	Final Interval (days)
Hanford (Loam) (20°C, pH 7.0)	DCSA	33.4	30	2.7	120
Fayette (Silt loam) (20°C, pH 7.2)	DCSA	29.6	21	4.1	120
MSL (Sandy loam) (20°C, pH 6.6)	DCSA	35.6	14	1.3	120
RMN (Loamy sand) (20°C, pH 6.9)	DCSA	26.1	30	2.4	120

Data obtained from Table 9, p. 48, Table 10, p. 50, Table 11, p. 52, and Table 12, p. 54 of the study report

An aerobic transformation pathway in soil was proposed by the study author (Figure 22, p. 79).



III. STUDY DEFICIENCIES AND REVIEWER'S COMMENTS

1. Unextracted residues reached a maximum of 67.7% of the applied at 120 days in the loam soil, 72.2% at 120 days in the silt loam soil, 71.0% at 30 days in the sandy loam soil, and 66.2% at 120 days in the loamy sand soil at 120 days posttreatment (Tables 5-8, pp. 44-47). In efforts to further extract residues, the study author used tetrahydrofuran (polar solvent) and hexane (non-polar solvent) to maximize extraction of the residues (pp. 25-26). For all four test soils, further extraction tetrahydrofuran and hexane only released ≤2.66% additional radioactivity (pp. 31-32). As a result, the unextracted residues are considered strongly bound.

2. The pesticide use histories for all of the test sites were not reported. It was only stated that for the California soil collection site, the soil was not treated with the test substance or its structural analogs, and that the other three soil collection sites were pesticide free (p. 19; Appendix 3, pp. 108-117). It was not confirmed that the test soils were free of pesticides prior to use in the study.

3. The concentration of residues remaining in the soil (humin) was determined by subtraction (p. 26). Measurement of humin by LSC following combustion of the extracted soil is preferred.

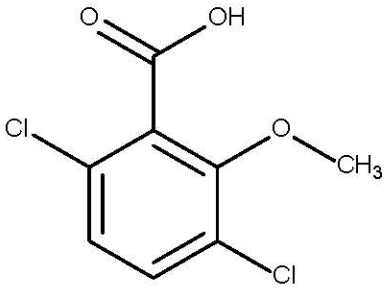
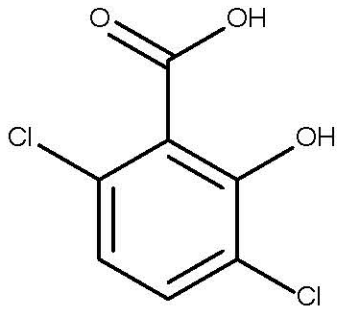
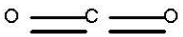
4. The flasks were connected in a series to a volatile trapping system (p. 23). It is preferred that sample vessels be connected to individual volatile traps so that more precise material balances for each sample can be calculated.

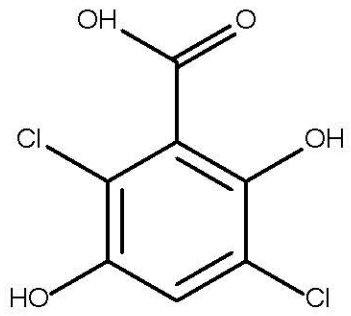
IV. REFERENCES

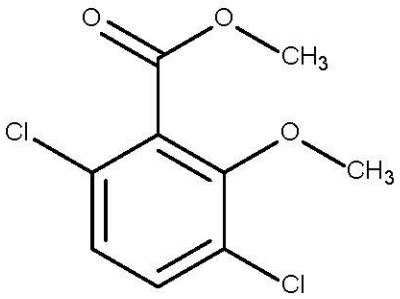
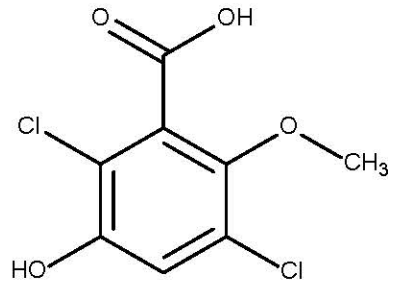
1. U.S. Environmental Protection Agency. 2008. Fate, Transport and Transformation Test Guidelines, OCSPP 835.4100, Aerobic Soil Metabolism. Office of Chemical Safety and Pollution Prevention, Washington, DC. EPA 712-C-08-016.

2. U.S. Environmental Protection Agency (USEPA). Undated. Guidance for Evaluating and Calculating Degradation Kinetics in Environmental Media. NAFTA Technical Working Group on Pesticides.

DER ATTACHMENT 1. Dicamba and Its Environmental Transformation Products. [A]

Code Name/ Synonym	Chemical Name	Chemical Structure	Study Type	MRID	Maximum %AR (day)		Final %AR (study length)
PARENT							
Dicamba (Dicamba acid)	**IUPAC:** 3,6-Dichloro-o-anisic acid **CAS:** 3,6-Dichloro-2-methoxybenzoic acid **CAS No.:** 1918-00-9 **Formula:** $C_8H_6Cl_2O_3$ **MW:** 221.04 g/mol **SMILES:** COc1c(Cl)ccc(Cl)c1C(O)=O		835.4100 Aerobic soil metabolism	50931306	PRT		PRT
MAJOR (>10%) TRANSFORMATION PRODUCTS							
DCSA (3,6-Dichlorosalicylic acid)	**IUPAC:** 3,6-Dichloro-2-hydroxybenzoic acid **CAS:** 3,6-Dichloro-salicylic acid **CAS No.:** 3401-80-7 **Formula:** $C_7H_4Cl_2O_3$ **MW:** 207.01 g/mol **SMILES:** ClC1=CC=C(Cl)C(O)=C1C(O)=O		835.4100 Aerobic soil metabolism	50931306	Loam	**33.4%** (30 d)	2.7% (120 d)
					Silt loam	**29.6%** (21 d)	4.1% (120 d)
					Sandy loam	**35.6%** (14 d)	1.3% (120 d)
					Loamy sand	**26.1%** (30 d)	2.4% (120 d)
Carbon dioxide	**IUPAC:** Carbon dioxide **Formula:** CO_2 **MW:** 44 g/mol **SMILES:** C(=O)=O		835.4100 Aerobic soil metabolism	50931306	Loam	**25.6%** (120 d)	**25.6%** (120 d)
					Silt loam	**27.3%** (120 d)	**27.3%** (120 d)

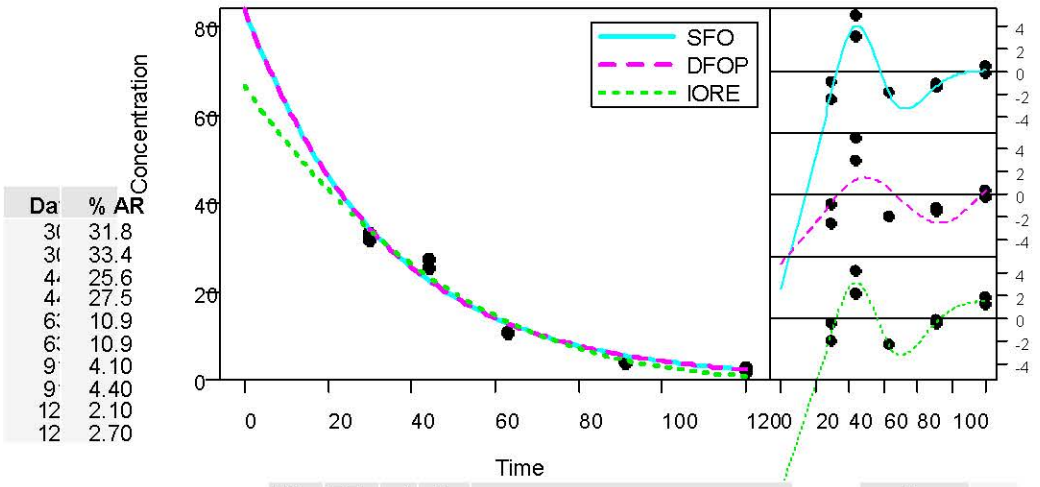
Code Name/ Synonym	Chemical Name	Chemical Structure	Study Type	MRID	Maximum %AR (day)		Final %AR (study length)
					Sandy loam	**34.2%** (120 d)	**34.2%** (120 d)
					Loamy sand	**26.1%** (120 d)	**26.1%** (120 d)
Unextractable residues	NA	NA	835.4100 Aerobic soil metabolism	50931306	Loam	**67.7%** (120 d)	**67.7%** (120 d)
					Silt loam	**72.2%** (120 d)	**72.2%** (120 d)
					Sandy loam	**71.0%** (30 d)	**64.6%** (120 d)
					Loamy sand	**66.2%** (120 d)	**66.2%** (120 d)
MINOR (<10%) TRANSFORMATION PRODUCTS							
No minor transformation products were identified.							
REFERENCE COMPOUNDS NOT IDENTIFIED							
2,5-Dichloro-3,6-dihydroxy-benzoic acid	**IUPAC:** 2,5-Dichloro-3,6-dihydroxybenzoic acid **CAS No.:** 18688-01-2 **Formula:** $C_7H_4Cl_2O_4$ **MW:** 223.01 g/mol **SMILES:** ClC1=CC(O)=C(Cl)C(C(O)=O)=C1O		835.4100 Aerobic soil metabolism	50931306	NA		NA

Code Name/ Synonym	Chemical Name	Chemical Structure	Study Type	MRID	Maximum %AR (day)	Final %AR (study length)
Dicamba methyl ester	**IUPAC:** Methyl 3,6-dichloro-2-methoxybenzoate **Formula:** $C_9H_8Cl_2O_3$ **MW:** 235.06 g/mol **SMILES:** ClC1=CC=C(Cl)C(C(OC)=O)=C1OC		835.4100 Aerobic soil metabolism	50931306	NA	NA
Dicamba-5-hydroxy (5-OH-Dicamba)	**IUPAC:** 2,5-Dichloro-3-hydroxy-6-methoxybenzoic acid **Formula:** $C_8H_6Cl_2O_4$ **MW:** 237.03 g/mol **SMILES:** ClC1=CC(O)=C(Cl)C(C(O)=O)=C1OC		835.4100 Aerobic soil metabolism	50931306	NA	NA

[A] AR means "applied radioactivity". MW means "molecular weight". PRT means "parent". NA means "not applicable".

DER Attachment 2: Statistics and Graphs

Aerobic metabolism of DCSA in Hanford loam soil

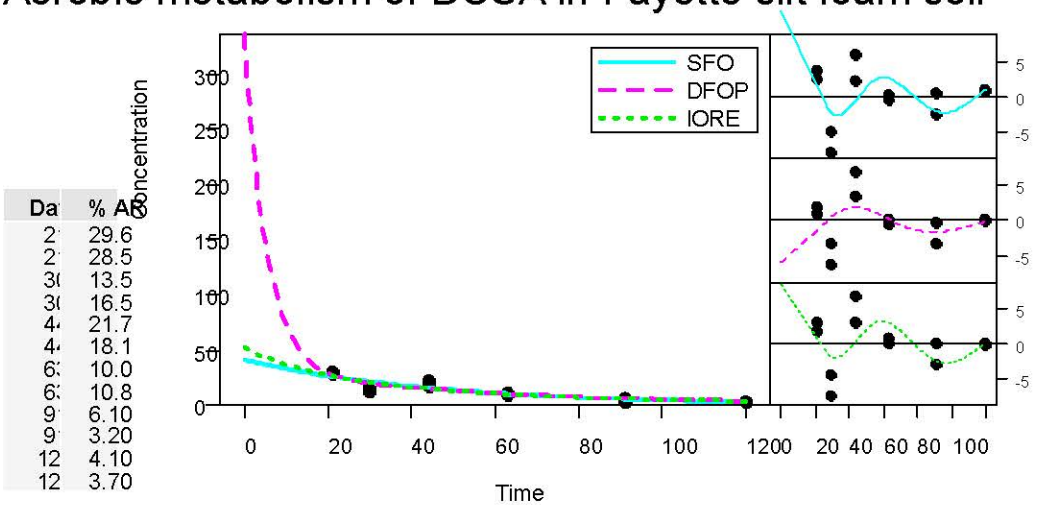


Da	% AR
3(	31.8
3(	33.4
4.	25.6
4.	27.5
6:	10.9
6:	10.9
9:	4.10
9:	4.40
12	2.10
12	2.70

	DT_{50}	DT_{90}	χ^2	C_0	Parameters
SF(	23	77	1	83	k = 0.0298
DF(	23	77	1	83	f = 0.875, k_0 = 0.0298, k_1 = 0.0298
IOR	30	8:	1	66	N = 0.706, k = 0.07

S_C	56.9
S_{SFO}	51.2
Slow $t_{1/2}$	23.3
t_{RIORE}	24.7

Aerobic metabolism of DCSA in Fayette silt loam soil



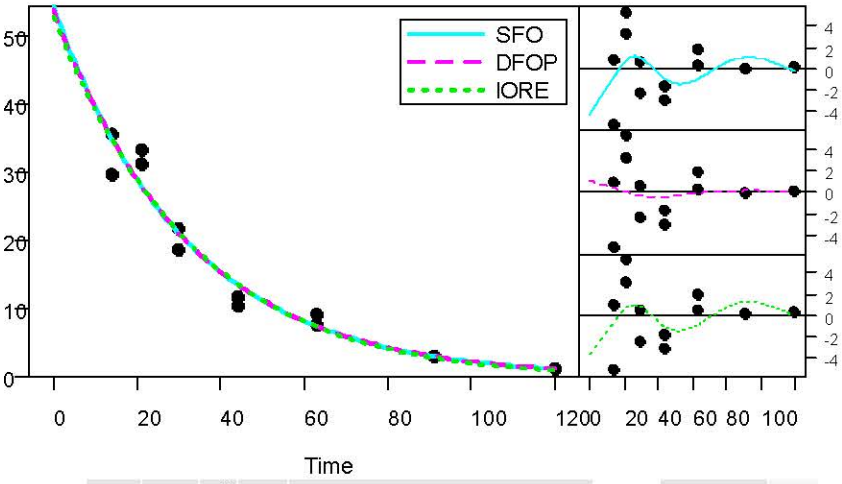
Da	% AR
2:	29.6
2:	28.5
3(	13.5
3(	16.5
4.	21.7
4.	18.1
6:	10.0
6:	10.8
9:	6.10
9:	3.20
12	4.10
12	3.70

	DT_{50}	DT_{90}	χ^2	C_0	Parameters
SF(	32	1(	1	4	k = 0.0216
DF(	4.1	17	2	3:	f = 0.906, k_0 = 0.189, k_1 = 0.0173
IOF	2:	1(	2	5	N = 1.37, k = 0.00817

S_C	195
S_{SFO}	154
Slow $t_{1/2}$	40.1
t_{RIORE}	30.6

Kinetics models: Single First Order (SFO); Double First Order in Parallel (DFOP), and Indeterminate Order Rate Equation (IORE). Calculated half-lives and model parameters in accordance with the NAFTA kinetics guidance.

Aerobic metabolism of DCSA in MSL sandy loam soil

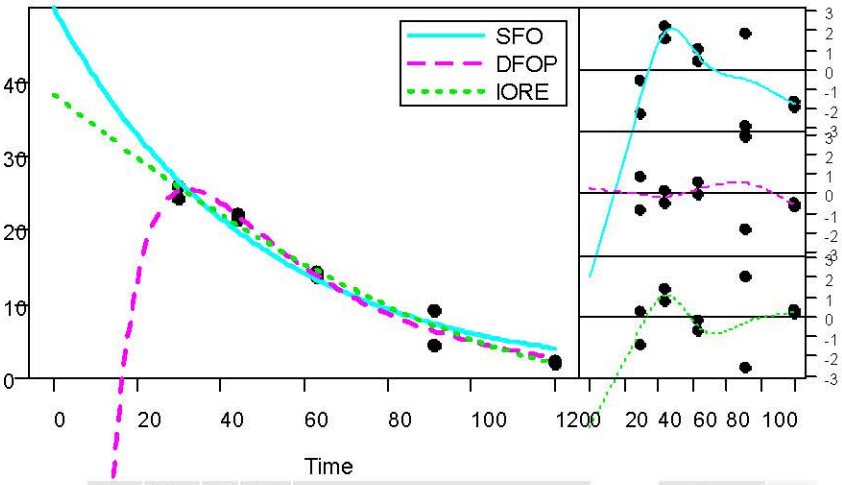


Da	% AR
1	29.6
1	35.6
2	33.2
2	31.2
3	18.8
3	21.7
4	11.9
4	10.6
6	7.80
6	9.30
9	3.00
9	3.00
12	1.30
12	1.30

	DT_{50}	DT_{90}	χ^2	C_0	Parameters
SF	2	73	1	54	k 0.0315
DF	22	73	1	53	f 1.2 k_0 0.0299 k_1 0.0246
IOF	2	7	1	52	N 0.943 k 0.0371

S_C	106
S_{SFO}	86.7
Slow DT_{50}	28.1
$t_{R\ IORE}$	22

Aerobic metabolism of DCSA in RMN loamy sand soil



Da	% AR
3	26.1
3	24.4
4	21.5
4	22.1
6	14.4
6	13.8
9	9.30
9	4.60
12	2.20
12	2.40

	DT_{50}	DT_{90}	χ^2	C_0	Parameters
SF	33	11	7.	49	k 0.0209
DF	4.4	N	3	-3	f 1.26 k_0 0.123 k_1 0.0277
IOF	48	1	4	38	N 0.425 k 0.0959

S_C	22.8
S_{SFO}	31.9
Slow DT_{50}	25
$t_{R\ IORE}$	32.6

Kinetics models: Single First Order (SFO); Double First Order in Parallel (DFOP), and Indeterminate Order Rate Equation (IORE). Calculated half-lives and model parameters in accordance with the NAFTA kinetics guidance.

DER Attachment 3: Calculations

Calculations were performed by the reviewer using PestDF, and the following equations.

Single First-Order (SFO) Model

$$C_t = C_0 e^{-kt} \quad \text{(eq. 1)}$$

where,

C_t = concentration at time t (%)
C_0 = initial concentration (%)
e = Euler's number (-)
k = SFO rate constant of decline (d^{-1})
t = time (d)

The SFO equation is solved with PestDF by adjusting C_0 and k to minimize the objective function (S_{SFO}) shown in equation 9.

DT_{50} = natural log (2)/k (eq. 2)

DT_{90} = ln (10)/k (eq. 3)

Indeterminate Order Rate Equation (IORE) Model

$$C_t = \left[C_0^{(1-N)} - (1-N)k_{IORE}t\right]^{\left(\frac{1}{1-N}\right)} \quad \text{(eq. 4)}$$

where,

N = order of decline rate (-)
k_{IORE} = IORE rate constant of decline (d^{-1})

This equation is solved with PestDF by adjusting C_0, k_{IORE}, and N to minimize the objective function for IORE (SIORE) (See equation 9). Half-lives for the IORE model are calculated using equation 5, which represents a first-order half-life that passes through the DT_{90} of the IORE model. (Traditional DT_{50} and DT_{90} values for the IORE model can be calculated using equations 6 and 7.)

$$t_{IORE} = \frac{\log(2)}{\log(10)} \frac{C_0^{1-N}(1-0.1^{(1-N)})}{(1-N)k_{IORE}} \quad \text{(eq. 5)}$$

$$DT_{50} = \frac{(C_0/2)^{(1-N)} - C_0^{(1-N)}}{k(N-1)} \quad \text{(eq. 6)}$$

$$DT_{90} = \frac{(C_0/10)^{(1-N)} - C_0^{(1-N)}}{k(N-1)} \quad \text{(eq. 7)}$$

Double First-Order in Parallel (DFOP) Model

$$C_t = C_0 g^{-k_1 t} + C_0(1-g)^{-k_2 t} \quad \text{(eq. 8)}$$

where,

g = the fraction of C_0 applied to compartment 1 (-)
k_1 = rate constant for compartment 1 (d^{-1})
k_2 = rate constant for compartment 2 (d^{-1})

If $C_0 \times g$ is set equal to a and $C_0(1-g)$ is set equal to c, then the equation can be solved with R kinetics software for a, c, k_1, and k_2 by minimizing the objective function (S_{DFOP}) as described in equation 9.

DT_{50} and DT_{90} values can be calculated using equations 2 and 3, with k_1 or k_2 in place of k.

Objective Function: SFO, IORE, and DFOP are solved by minimizing the objective function (S_{SFO}, S_{IORE}, or S_{DFOP}).

$$\mathbf{S_{SFO}, S_{IORE}, or\ S_{DFOP}} = \sum(C_{model,t} - C_{d,t})^2 \qquad \text{(eq. 9)}$$

where,

S_{SFO} , S_{IORE}, or S_{DFOP} = objective function of kinetics model fit ($\%^2$)
n = number of data points (-)
$C_{model,t}$ = modeled value at time corresponding to $C_{d,t}$ (%)
$C_{d,t}$ = experimental concentration at time t (%)

Critical Value to Determine Whether SFO is an Adequate Kinetics Model

If S_{SFO} is less than S_C, the SFO model is adequate to describe kinetics. If not, the faster of t_{IORE} or the DFOP DT_{50} for compartment 2 should be used.

$$S_c = S_{IORE}\left(1 + \frac{p}{n-p}F(\alpha, p, n-p)\right) \qquad \text{(eq. 10)}$$

where,

S_c = the critical value that defines the confidence contours ($\%^2$)
p = number of parameters (3 in this case)
α = the confidence level (0.50 in this case)
F(α, p, n-p) = F distribution with α level of confidence and degrees of freedom p and n-p

DER Attachment 4: Spreadsheet Calculations

029801_50931306_83
5.4100_Calculations.xls